nuclei resulting from the first division remain in the upper portion of the sac. One of these divides to form the two synergids, and the other forms the egg and polar nucleus. There are therefore no antipodals and only one polar nucleus. In fertilization one male nucleus unites with the egg; the other unites with the polar nucleus to form the endosperm.

The account of reduction phenomena confirms, in all the main points, the previous accounts of GATES.[24] There is no fusion of parallel threads in synapsis. The spirem later breaks into the vegetative number of chromosomes, which afterward become paired. The first mitosis separates whole chromosomes, and the second separates the longitudinal halves of these. Certain critical stages during the period between synizesis and diakinesis, which prove that the chromosomes are formed by the segmentation of a single spirem thread, are not represented; but these stages are the most difficult to obtain, probably because they are passed through quickly. It seems now pretty evident that there are two general methods of reduction in plants, as in animals, one involving a telosynapsis, the other a parasynapsis or side-by-side pairing of chromosomes.

The question of sterility is also examined, with interesting results. In *Oenothera Lamarckiana* 50 per cent. of the ovules are found to degenerate, and about 50 per cent. of the pollen grains—two from each tetrad of spores. A large number of other Onagraceae were examined, nearly all of which were found to exhibit more or less sterility. GEERTS concludes that the sterility of *O. Lamarckiana* cannot be explained as the result of hybridization, cultivation, or lack of nutrition or space, but that it has been inherited from a remote ancestor, probably from the ancestor of the whole sub-family. He thinks that since this sterility is heritable it must have originated by a mutation, or rather two mutations, one on the pollen side and one on the megaspore side, since they are often sterile in different degrees in the same species!

So far from explaining anything, it seems to the reviewer that this muddies the pool and is much worse than a flat confession of ignorance as to the cause. It will be unfortunate if botanists acquire the habit of ascribing the origin of complex conditions, such as sterility, to a sudden "mutation" in some ancestor. There is no evidence to show that the sterility has not been gradually acquired, and for that matter independently acquired, in the different species. To call it a mutation helps to explain neither its origin nor its cause.—R. R. GATES.

Seedlings of conifers.—HILL and FRAINE[25] have published a second paper on the seedlings of gymnosperms, the thesis being that polycotyledony is attained by the splitting of preexisting members, which were probably two in number. In the present investigation seedlings of Tsuga, Abies, Picea, Cedrus, Pinus, Larix, Pseudolarix, and Araucaria were studied. The general result shows that

[24] GATES, R. R., A study of reduction in *Oenothera rubrinervis*. BOT. GAZETTE 46:1–34. *pls. 1–3.* 1908.

[25] HILL, T. G., AND DE FRAINE, E., On the seedling structure of gymnosperms. Annals of Botany 23:189–227. *pl. 15. figs. 11.* 1909.

the Taxineae, Podocarpineae, and many Cupressineae have two cotyledons, and that each cotyledon (Podocarpineae being excepted) contains one vascular strand and the primary root is diarch. Among the Abietineae, however, in which polycotyledony prevails, each cotyledon has a single vascular strand, but the number of poles of the primary root holds no obvious relation to the number of cotyledons.

In summarizing the evidence of splitting, the authors add the following testimony: the occurrence of partially split cotyledons, the frequent obvious grouping of cotyledons, and the cases of transition. *Pinus contorta Murrayana* may be selected as an illustration of the last case, in which form three entire cotyledons were found, one of them much larger than the other two and containing two entirely distinct vascular strands. The authors speak of this as a case of one whole cotyledon and two half-cotyledons. Trouble of course comes with the higher numbers of cotyledons, and at this point the explanation offered is not clear. It is acknowledged that in some cases an increased number of cotyledons may result from the appearance of extra primordia, which represent the displacement of foliage leaves from the first stem node to the cotyledonary node.

The general summary of facts contains the following items: the occurrence of more or less complete cotyledonary tubes (over 20 species cited); the existence of cases of incomplete splitting (4 species cited); the general presence of cotyledonary resin ducts (several in araucarians, two in 12 species cited, one in 6 species, and none in 6 species or more); the occurrence of 4–8 vascular strands in each cotyledon of Araucaria, and of one strand in the cotyledons of Tsuga, Abies, Picea, Cedrus, Pinus, and Larix; the occurrence of mesarch structure in occasional cotyledons of *Tsuga canadensis*, *Pinus Pinea*, and *P. Gerardiana*.

SHAW[26] has investigated the seedling of *Araucaria Bidwillii*, a tuberous species and one not studied by HILL and FRAINE. He finds that the cotyledonary vascular strands are very numerous and variable (12 to 16), that the poles of the root are equally variable (5 to 7), and that there is a very confused connection between the two. The protoxylem groups of the root are gradually reduced until the diarch condition is finally attained.—J. M. C.

The Piccard rotation experiments.—HABERLANDT[27] has repeated PICCARD'S rotation experiments,[28] for which he used the seedlings of *Vicia Faba*, *Lupinus albus*, and *Phaseolus multiflorus*. He characterizes PICCARD'S conception as good, but the execution of the experiments and the interpretation of the results as faulty.

He claims to have eliminated all PICCARD'S technical errors by devising a very substantial and accurate centrifuge, and by securely fastening the seedlings

[26] SHAW, F. J. F., The seedling structure of *Araucaria Bidwillii*. Annals of Botany 23:321–334. *pl. 21. figs. 6.* 1909.

[27] HABERLANDT, G., Ueber die Verteilung der geotropischen Sensibilität in der Wurzel. Jahrb. Wiss. Bot. 45:575–600. 1909.

[28] PICCARD, AUGUST, Neue Versuche über die geotropische Sensibilität der Wurzelspitze. Jahrb. Wiss. Bot. 40:94–102. 1904.